Claims

We claim:

1. A method for changing an electrical resistance of a resistor, comprising:

providing a resistor having a length L and a first electrical resistance R_1; and

exposing a portion of the resistor to a laser radiation for a time of exposure, wherein the portion of the resistor includes a fraction F of the length L, wherein at an end of the time of exposure the resistor has a second electrical resistance R_2, and wherein R_2 is unequal to R_1.

2. The method of claim 1, wherein a spot dimension of the laser radiation is less than a product of F and L.

3. The method of claim 1, wherein $F = 1$, and wherein at the end of the exposing step the resistor has partially reacted with the laser radiation.

4. The method of claim 1, wherein $F = 1$, and wherein at the end of the exposing step the resistor has fully reacted with the laser radiation.

5. The method of claim 1, wherein $F < 1$, and wherein at the end of the exposing step the resistor has partially reacted with the laser radiation.

6. The method of claim 1, wherein $F < 1$, and wherein at the end of the exposing step the resistor has fully reacted with the laser radiation.

7. The method of claim 1, wherein $R_2 > R_1$.

8. The method of claim 1, wherein $R_2 < R_1$.

9. The method of claim 1, wherein a product of F and L does not exceed about 1 micron.

10. The method of claim 1, wherein the resistor in the providing step includes a layer of a first electrically conductive material in electrically conductive contact with a layer of a second electrically conductive material, wherein the exposing step causes a portion of the first electrically conductive material to react with a portion of the second electrically conductive material to form a cell of a third electrically conductive material within the portion of the resistor.

11. The method of claim 10, wherein $R_2 > R_1$.

12. The method of claim 11, wherein the first electrically conductive material includes titanium, wherein the second electrically conductive material includes aluminum, and wherein the third electrically conductive material includes titanium trialuminide.

13. The method of claim 10, wherein $R_2 < R_1$.

14. The method of claim 13, wherein the first electrically conductive material includes cobalt, wherein the second electrically conductive material includes silicon, and wherein the third electrically conductive material includes cobalt silicide.

15. The method of claim 1, wherein the resistor in the providing step includes an amorphous metallic material, wherein the exposing step transforms a portion of the amorphous metallic material into a crystalline metallic material within the portion of the resistor.

16. The method of claim 15, wherein the amorphous metallic material is selected from the group consisting of titanium nitride, tantalum silicon nitride, and tungsten nitride.

17. The method of claim 1, wherein the resistor in the providing step includes a polycrystalline metal, wherein the exposing step transforms a first crystalline phase of the polycrystalline metal into a second crystalline phase of the polycrystalline metal within the portion of the resistor.

18. The method of claim 17, wherein the polycrystalline metal includes tantalum, wherein the first crystalline phase includes a tetragonal phase, and wherein the second crystalline phase includes a body-centered cubic phase.

19. The method of claim 1, wherein the resistor in the providing step includes a metallic oxide selected from the group consisting of a metal oxide and a metallic alloy oxide, wherein the exposing step reacts a portion of the metallic oxide to form a metallic component and oxygen gas within the portion of the resistor, wherein the metallic component is the metal if the metallic oxide is the metal oxide, and wherein the metallic component is the metallic alloy if the metallic oxide is the metallic alloy oxide.

20. The method of claim 19, wherein the metal oxide is platinum oxide, palladium oxide, iridium oxide, or platinum palladium oxide.

21. The method of claim 1, wherein the resistor in the providing step includes N layers denoted as layers 1, 2, ..., N, wherein N is at least 2, wherein layer I includes an electrically conductive material M_I for I = 1, 2, ..., N, wherein layer J is in electrically conductive contact with layer J+1 for J = 1, 2, ..., N-1, wherein the exposing step causes a portion of the electrically conductive material M_K to react with a portion of the electrically conductive material M_{K+1} to form an electrically conductive cell $C_{K,K+1}$ within the portion of the resistor, and wherein K is selected from the group consisting of 1, 2, ..., N-1, and combinations thereof.

22. The method of claim 1, further comprising exposing the portion of the resistor to the laser radiation for an additional period of time, resulting in the resistor having a third electrical resistance that differs from the second electrical resistance.

23. The method of claim 1, further comprising exposing the portion of the resistor to the laser radiation for an additional period of time, resulting in the resistor having a third electrical resistance that is about equal to the second electrical resistance.

24. The method of claim 1, wherein the resistor is coupled to a semiconductor substrate.

25. The method of claim 24, wherein the substrate includes an insulator and a plate, wherein the insulator is disposed between the resistor and the plate, and wherein the plate is capable of absorbing the laser radiation.

26. The method of claim 24, wherein the plate includes a metal.

27. The method of claim 25, further comprising exposing the plate to a portion of the laser radiation, wherein the portion of the laser radiation does not pass through a total thickness of the plate.

28. The method of claim 24, further comprising:

providing a predetermined target resistance in terms of a value R_t and a tolerance ΔR_t for the second electrical resistance; and

testing the resistor after the exposing step to determine whether the second electrical resistance is within $R_t \pm \Delta R_t$.

29. The method of claim 28, wherein after the testing step the second electrical resistance is not within $R_t \pm \Delta R_t$, and further comprising if $(R_2-R_1)(R_t-R_2) > 0$ iterating such that each iteration of the iterating includes:

additionally exposing the portion of the resistor to the laser radiation resulting in a new second electrical resistance R_2';

additionally testing the resistor after the additionally exposing step to determine whether R_2' is within $R_t \pm \Delta R_t$, and ending the iterating if R_2' is within $R_t \pm \Delta R_t$ or if $(R_2'-R_1)(R_t-R_2') < 0$.

30. The method of claim 24, further comprising:

providing a predetermined target resistance in terms of a value R_t and a tolerance ΔR_t for the second electrical resistance; and

testing the resistor during the exposing step to determine whether the second electrical resistance is within $R_t \pm \Delta$.

31. The method of claim 30, wherein during the testing step the second electrical resistance is not within $R_t \pm \Delta R_t$, and further comprising if $(R_2-R_1)(R_t-R_2) > 0$ iterating such that each iteration of the iterating includes additionally testing the resistor during the exposing step to determine whether R_2'' is within $R_t \pm \Delta R_t$, and ending the iterating if R_2'' is within $R_t \pm \Delta R_t$ or if $(R_2''-R_1)(R_t-R_2'') < 0$, wherein R_2'' is a latest value of the second electrical resistance as determined by the testing.

32. The method of claim 31, wherein the laser radiation is selected from the group consisting of a continuous laser radiation and a pulsed laser radiation.

33. The method of claim 24, further comprising:

conductively coupling a first electrically conductive contact to the resistor;

conductively coupling a second electrically conductive contact to the resistor; and

conductively coupling an electrical circuit element to the first electrically conductive contact and to the second electrically conductive, wherein an electrical circuit is formed such that the electrical circuit includes the electrical circuit element and the resistor.

34. An electrical structure, comprising:

a resistor having a length L and an electrical resistance $R(t)$ at a time t; and

a laser radiation directed onto a portion of the resistor, wherein the portion of the resistor includes a fraction F of the length L, and wherein the laser radiation heats the portion of the resistor such that the electrical resistance $R(t)$ instantaneously changes at a rate dR/dt.

35. The electrical structure of claim 34, wherein a spot dimension of the laser radiation is less than the length L.

36. The electrical structure of claim 34, wherein $F = 1$.

37. The electrical structure of claim 34, wherein $F < 1$.

38. The electrical structure of claim 34, wherein $dR/dt > 0$.

39. The electrical structure of claim 34, wherein $dR/dt < 0$.

40. The electrical structure of claim 34, wherein $dR/dt = 0$.

41. The electrical structure of claim 34, wherein a product of F and L does not exceed about 1 micron.

42. The electrical structure of claim 34, wherein the resistor includes a layer of a first electrically conductive material coupled to a layer of a second electrically conductive material by a cell of a third electrically conductive material that is within the portion of the resistor, and wherein the third electrically conductive material includes a chemical combination of the first electrically conductive material and the second electrically conductive material.

43. The electrical structure of claim 42, wherein $dR/dt > 0$.

44. The electrical structure of claim 43, wherein the first electrically conductive material includes titanium, wherein the second electrically conductive material includes aluminum, and wherein the third electrically conductive material includes titanium trialuminide.

45. The electrical structure of claim 42, wherein $dR/dt < 0$.

46. The electrical structure of claim 45, wherein the first electrically conductive material includes cobalt, wherein the second electrically conductive material includes silicon, and wherein the third electrically conductive material includes cobalt silicide.

47. The electrical structure of claim 34, wherein the resistor comprises an amorphous metallic material, wherein a cell of the amorphous metallic material within the portion of the resistor is coupled to a cell of a crystalline metallic material within the portion of the resistor, and wherein the crystalline metallic material has resulted from an interaction of the laser radiation with the

amorphous metallic material.

48. The electrical structure of claim 47, wherein the amorphous metallic material is selected from the group consisting of titanium nitride, tantalum silicon nitride, and tungsten nitride.

49. The electrical structure of claim 34, wherein the resistor comprises a polycrystalline metal having a first crystalline phase, wherein a cell of the polycrystalline metal within the portion of the resistor is coupled to a cell of a second crystalline phase of the polycrystalline metal within the portion of the resistor, and wherein the second phase of the polycrystalline metal has resulted from an interaction of the laser radiation with the first phase of the polycrystalline metal.

50. The electrical structure of claim 49, wherein the polycrystalline metal includes tantalum, wherein the first crystalline phase includes a tetragonal phase, and wherein the second crystalline phase includes a body-centered cubic phase.

51. The electrical structure of claim 34, wherein the resistor comprises a metallic oxide selected from the group consisting of a metal oxide and a metallic alloy oxide, wherein a cell of the metallic oxide within the portion of the resistor is coupled to a cell of a metallic component within the portion of the resistor, wherein the metallic component is the metal if the metallic oxide is the metal oxide, wherein the metallic component is the metallic alloy if the metallic oxide is the metallic alloy oxide, and wherein the metallic component has resulted from an interaction of the laser radiation with the metallic oxide.

52. The electrical structure of claim 51, wherein the metallic oxide is platinum oxide, palladium oxide, irridium oxide, or platinum palladium oxide.

53. The electrical structure of claim 34,

wherein the resistor comprises N layers denoted as layers 1, 2, ..., N;

wherein N is at least 2;

wherein layer I includes an electrically conductive material M_I for I=1, 2, ... , N;

wherein layer J is in electrically conductive contact with layer J+1 for J = 1, 2, ..., N-1; and

wherein a cell $C_{K,K+1}$ couples a cell C_K' of the layer K to a cell C_{K+1}' of the layer K+1, wherein the cell C_K' is within the portion of the resistor and includes the material M_K, wherein the cell C_{K+1}' is within the portion of the resistor and includes the material M_{K+1}, wherein the cell $C_{K,K+1}$ is within the portion of the resistor and includes an electrically conductive material $M_{K,K+1}$ that comprises a chemical combination of the material M_K from the layer K and the material M_{K+1} from the layer K+1, and wherein K is selected from the group consisting of 1, 2, ..., N-1, and combinations thereof.

54. The electrical structure of claim 34, wherein the resistor is coupled to a semiconductor substrate.

55. An electrical resistor of length L, comprising N layers denoted as layers 1, 2, ..., N:

wherein a portion of the resistor includes a fraction F of the length L;

wherein N is at least 2;

wherein layer I includes an electrically conductive material M_I for I=1, 2, ... , N;

wherein layer J is in electrically conductive contact with layer J+1 for J = 1, 2, ..., N-1; and

wherein a cell $C_{K,K+1}$ couples a cell C_K' of the layer K to a cell C_{K+1}' of the layer K+1, wherein the cell C_K' is within the portion of the resistor and includes the material M_K, wherein the cell C_{K+1}' is within the portion of the resistor and includes the material M_{K+1}, wherein the cell $C_{K,K+1}$ is within the portion of the resistor and includes an electrically conductive material $M_{K,K+1}$ that comprises a chemical combination of the material M_K from the layer K and the material M_{K+1} from the layer K+1, and wherein K is selected from the group consisting of 1, 2, ..., N-1, and combinations thereof.

56. The electrical resistor of claim 55, wherein F = 1.

57. The electrical resistor of claim 55, wherein F < 1.

58. The electrical resistor of claim 55, wherein a product of F and L does not exceed about 1 micron.

59. The electrical resistor of claim 55, wherein N =2.

60. The electrical resistor of claim 59, wherein the electrically conductive material M_1 includes titanium, wherein the electrically conductive material M_2 includes aluminum, and wherein the electrically conductive material $M_{1,2}$ includes titanium trialuminide.

61. The electrical resistor of claim 59, wherein the electrically conductive material M_1 includes cobalt, wherein the electrically conductive material M_2 includes aluminum, and wherein the electrically conductive material $M_{1,2}$ includes cobalt silicide.

62. The electrical resistor of claim 55, further comprising:

a semiconductor substrate coupled to the resistor;

a first electrically conductive contact conductively coupled to the resistor;

a second electrically conductive contact conductively coupled to the resistor; and

an electrical circuit element coupled to the first electrically conductive contact and to the second electrically conductive, wherein an electrical circuit includes the electrical circuit element and the resistor.

63. An electrical resistor of length L, comprising:

a first portion having a length L_1, wherein the first portion includes at least one cell having an electrically conductive material with a first structure; and

a second portion of length L_2 such that $L_2 = L - L_1$, wherein the second portion includes a fraction F of the length L such that $F = L_2/L$, wherein the second portion includes a structured cell having the electrically conductive material with a second structure, and wherein the electrically conductive material with the second structure has resulted from a laser heating of the electrically conductive material with the first structure.

64. The electrical resistor of claim 63, wherein the first structure includes an amorphous metallic material structure, and wherein the second structure includes a crystalline metallic structure.

65. The electrical resistor of claim 64, wherein the amorphous metallic material structure includes an amorphous metallic material selected from the group consisting of titanium nitride, tantalum silicon nitride, and tungsten nitride.

66. The electrical resistor of claim 63, wherein the electrically conducting material includes a polycrystalline metal, wherein the first structure includes a first crystalline phase, and wherein the second structure includes a second crystalline phase.

67. The electrical resistor of claim 66, wherein the polycrystalline metal includes tantalum, wherein the first crystalline phase includes a tetragonal phase, and wherein the second crystalline

phase includes a body-centered cubic phase.

68. The electrical resistor of claim 63, wherein the first structure includes a metallic oxide selected from the group consisting of a metal oxide and a metallic alloy oxide, and wherein the second structure includes a metallic component, wherein the metallic component is the metal if the metallic oxide is the metal oxide, and wherein the metallic component is the metallic alloy if the metallic oxide is the metallic alloy oxide.

69. The electrical resistor of claim 68,wherein the metal oxide is platinum oxide, palladium oxide, irridium oxide, or platinum palladium oxide.

70. The electrical resistor of claim 63, wherein the second portion further comprises a first structured cell that includes the electrically conductive material with the first structure, and wherein the first structured cell is coupled to the structured cell.

71. The electrical resistor of claim 63, wherein the at least one cell includes a first cell and a second cell, and wherein the structured cell is disposed between the first cell and the second cell.

72. The electrical resistor of claim 63, wherein $F = 1$.

73. The electrical resistor of claim 63, wherein $F < 1$.

74. The electrical resistor of claim 63, wherein a product of F and L does not exceed about 1 micron.

75. The electrical resistor of claim 63, further comprising:

a semiconductor substrate coupled to the resistor;

a first electrically conductive contact conductively coupled to the resistor;

a second electrically conductive contact conductively coupled to the resistor; and

an electrical circuit element coupled to the first electrically conductive contact and to the second electrically conductive, wherein an electrical circuit includes the electrical circuit element and the resistor.